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P01/7700 0.00-0222073.9

1. Your reference — HL77286/000/CIV

2. Patent application number *(The Patent Office will fill in this part)* — 0222073.9

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)
   SE-126 25 Stockholm
   Sweden

   Patents ADP number *(if you know it)* — 6410895001

   If the applicant is a corporate body, give the country/state of its incorporation — SE

4. Title of the invention

   TELECOMMUNICATIONS NETWORKS

5. Name of your agent *(if you have one)* — Haseltine Lake

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Imperial House
   15-19 Kingsway
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   WC2B 6UD

   Patents ADP number *(if you know it)* — 34001

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Number of earlier application	Date of filing *(day / month / year)*

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Description	6
Claim*(s)*	2 CF
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
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11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 23/9/02

12. Name and daytime telephone number of person to contact in the United Kingdom — Mr C I Vigars [0117] 910 3200

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DUPLICATE

TELECOMMUNICATIONS NETWORKS

The present invention relates to telecommunications networks, and in particular to third generation mobile telephone networks and systems.

BACKGROUND OF THE INVENTION

In third generation mobile telephony systems, power control is important to obtain desirably high capacity and efficiency, particularly in CDMA systems. The variable that is controlled is called quality. Quality of the communication is controlled with reference to one of two quality measurements: BER (Bit Error Rate) or FER (Frame Erasure Rate). Usually an integrating controller is provided to achieve a steady state of performance with zero control error. The control scheme used is cascade control, see for example Figure 1 of the accompanying drawings. The idea with cascade control is to make an inner control loop (2) much faster than an outer control loop (4). For transmission power control (TPC) the inner loop controls signal to interference ratio (SIR). The outer loop sets the SIR reference value SIR_r for the inner loop. The goal of the outer loop is to control the SIR reference to achieve a BER that is equal to the BER reference BER_r. To get a control system that in steady state achieves a BER that is equal to the BER reference, an integrating controller (9) can be used. The cascade controller illustrated in Figure 1 comprises an inner control loop (2) and an outer control loop (4). Both control loops have an input of a received signal (y(k)). The outer control loop 4 serves to estimate the BER (5) for comparison with a BER reference signal. A subtracter (7) calculates the difference between the reference signal and the BER

estimate to supply an input signal to an integrating controller (9). The integrating controller (9) produces a SIR reference signal.

The SIR reference signal is compared with an SIR estimate from an SIR estimation unit (3) in the inner control loop (2). The difference between the SIR reference and the SIR estimate is supplied to a step controller (11) for determining the transmission power of the output signal u(k).

A known problem with an integrating controller is that it becomes unstable if the control signal saturates. This problem is often referred to as the windup problem. TPC saturation of the control signal corresponds to situations when the maximum transmitter power is used.

The problem with windup in the power control algorithms for third generation mobile telephony systems is well known. However no solutions to the problem have yet been presented. The specific problem of which protection is WCDMA makes several additions to anti-windup schemes used in other areas necessary.

As is well known, integrating controllers have the nice property of being able to achieve zero control error in steady state. As an example of an integrating controller, a continuous time PI-controller is shown in Figure 2, which illustrates a continuous time controller. Discrete time controllers have similar behaviour. For example, Karl Johan Åström and Tore Hägglund. PID Controllers: Theory, Design and Tuning. Instrument Society of America, Research Triangle Park, NC, second edition, 1995.

A known problem with integrating controllers is that the integrator part turns unstable when the control signal saturates. This instability occurs because feedback from the process is needed to

stabilize the controller, which is not open loop stable. In the case of transmission power control, saturation can occur when maximum transmission power is used. In this situation the transmission power can only be decreased, which can be seen as open loop operation of the integrator.

As the controller is not open loop stable the controller state (the integrator, I-part) can start to build up a large state. This usually results in that it takes a long time for the control loop to start functioning again after the saturation state is left. This problem is usually referred to as the windup problem.

SUMMARY OF THE PRESENT INVENTION

An embodiment of the present invention can provide a method for controlling a radio frequency (RF) transmitter, the method comprising:

using an integrating controller to produce a required signal-to-interference ratio (SIR) signal from a desired error signal;

producing an estimated SIR signal to the integrating controller as a feedback signal, thereby stabilising the required signal-to-interference ratio (SIR).

It is emphasised that the term "comprises" or "comprising" is used in this specification to specify the presence of stated features, integers, steps or components, but does not preclude the addition of one or more further features, integers, steps or components, or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a controller for a third generation mobile system;

Figure 2 illustrates an integrating controller; and

Figures 3 to 5 illustrate respective controllers embodying the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

To explain the invention, a simplified model for the controlled process is derived, and is illustrated in Figure 3. The SIR control loop is modelled as a saturation (21) and a delay (23).

The process that maps SIR to BER (BLER) is modelled as a static function (25). This is not important for the invention and can be modelled by any suitable means. A problem is that SIR and BER (BLER) cannot be directly measured. SIR and BER (BLER) can only be estimated. This is indicated in Figure 3 with two estimation noises W_R.

When transmission power saturates (i.e. when the maximum transmission power is reduced) SIR will no longer follow SIR_r (SIR reference). In the tracking approach of the present invention the difference between SIR and SIR_r is calculated and fed back to stabilize the integrating controller. If v_K is small the difference will be small, except when the transmission power is saturated. The tracking solution is shown in Figure 4. The PI-controller with tracking signal input to the integrator is shown in Figure 5. As before, a continuous time loop is shown, but a discrete time version is simply derived and would have similar behaviour. Embodiments of the present invention are applicable to transmission power control systems in both the up-link and the down-link.

Figure 4 is a schematic illustration of a tracking solution embodying the present invention. The components of Figure 3 are shown, namely the saturation

21, delay 23 and the static mapping function 25. A required SIR (SIR_r)is input to this model to produce an SIR estimate (SIR est) and a BER estimate (BER est).

The tracking solution is illustrated by elements 31, 33, 35, 37, 39 and 41. A required BER (BER_r)is supplied via a log function 31 to an adder 33. Also supplied the adder 33 is the BER estimate, via a log function 41, so that the adder 33 produces an error result equal to the difference between the required BER and the estimated BER. The log functions are introduced to ensure that the control loop behaves in a linier fashion. A controller 35 (CBER) receives as one input the error signal E. The controller also receive a tracking signal PS. The controller produces a signal representing the required SIR for supply to the SIR control loop model. The required SIR signal is also supplied, via a delay element 37, to an adder 39 which produces the tracking signal by subtracting the required SIR signal from the estimated SIR signal.

Figure 5 illustrates the controller 35 in more detail. As can be seen, the controller includes a gain element 43 of gain K which receives an input e as supplies an output eK to an adder 44. The error signal e is also supplied to a component 45 having a transfer function K/T_i (where T_i is the integration time) for supplying to another adder 46. A second input of the adder 46 is provided by the output from a second component 49 having a transfer function $1/T_t$ (where T_t is the tracking time) as supplied with the error signal ES. The output of the adder 46 is integrated by the integrator 47 (1/s) and supplied to the adder 44. The output of the adder 44 gives the required SIR signal. It can be seen that the controller 35 provides the following transfer function as given in equation 1.

$$SIR_r = eK + \frac{1}{s}\left(\frac{eK}{T_i} + \frac{e_s}{T_t}\right)$$

An alternative implementation would be to use the estimated tracking signal e_s to do "conditional integration". In such an implementation the integrator part is not updated if e_s is larger than a threshold, i.e. if $|e_s| > e_{threshold}$ the integrator is not updated. This solution also prevents the integrator state to build up a large value in scenarios of power saturation.

The best practice implementation of the tracking arrangement includes to do some filtering of e_s and a dead zone. This makes the impact of estimation errors smaller in cases of not saturating power.

The invention is a new application of the tracking approach to the windup problem. To the knowledge of the inventor, tracking has not before been used to tackle the problem of saturation in transmission power control. The major improvement compared to existing approaches are that the saturation is estimated by comparing SIR_r and SIR_{est}. Without this feature it would not be possible to generate a tracking signal. The invention is applicable to transmission power control systems in both the up-link and the down-link.

CLAIMS

1. A method for controlling a radio frequency (RF) transmitter, the method comprising:

using an integrating controller to produce a required signal-to-interference radio (SIR) signal from a desired error signal;

producing an estimated SIR signal relating to an actual SIR of the RF transmitter; and

supplying the estimated SIR signal to the integrating controller as a feedback signal, thereby stabilising the required signal-to-interference ratio (SIR_r).

2. A radio frequency transmitter controller comprising:

an integrating controller operable to produce a desired signal-to-interference ratio (SIR) signal from an input error signal; and

an estimation unit, connected to receive a sampled output signal, and operable to produce an estimated SIR signal relating to a sampled output signal,

wherein the estimation unit is operable to supply the estimated SIR signal to the integrating controller, and the integrating controller is operable to produce the desired SIR signal from the input error signal and the estimated SIR signal.

3. A controller as claimed in claim 2, wherein the integrating controller has the transfer function:

$$SIR_r = eK + \frac{1}{s}\left(\frac{eK}{T_i} + \frac{e_s}{T_t}\right)$$

in which SIR_r is the desired SIR signal, e is the input error signal, K is a constant, e_s is the estimated SIR signal and T_i and T_t are time constants relating to

the integration and estimation unit respectively.

4. A controller as claimed in claim 2 or 3, wherein the desired SIR signal is set to produce a desired bit error rate (BER) at the output of the transmitter.

ABSTRACT

Telecommunications Networks

A RF transmitter in a telecommunications network is controlled using an integrating controller. An estimated SIR signal is used as a feedback signal for the integrating controller.

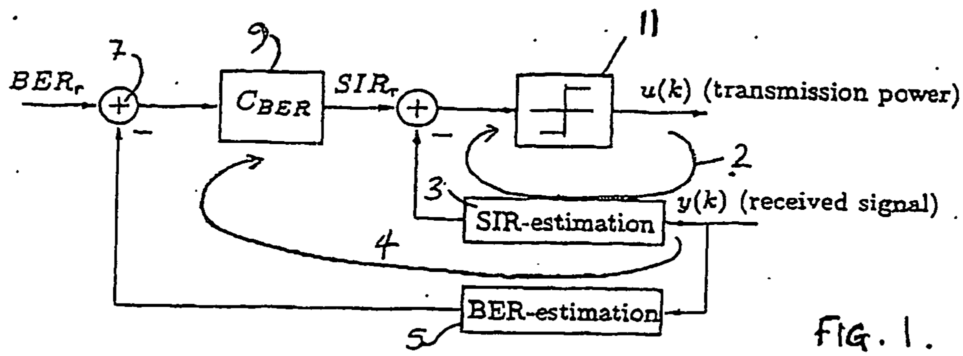

FIG. 1.

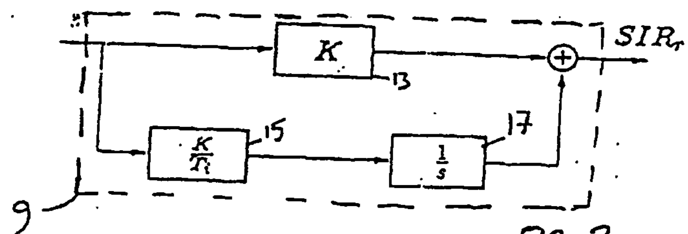

FIG. 2.

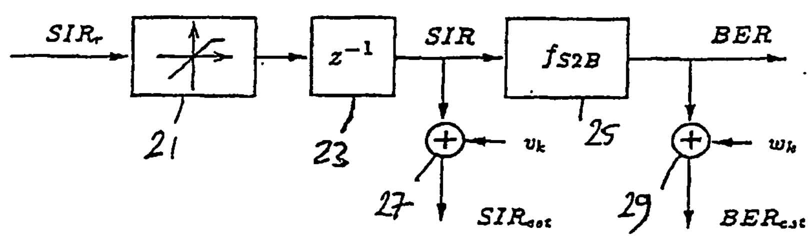

FIG. 3

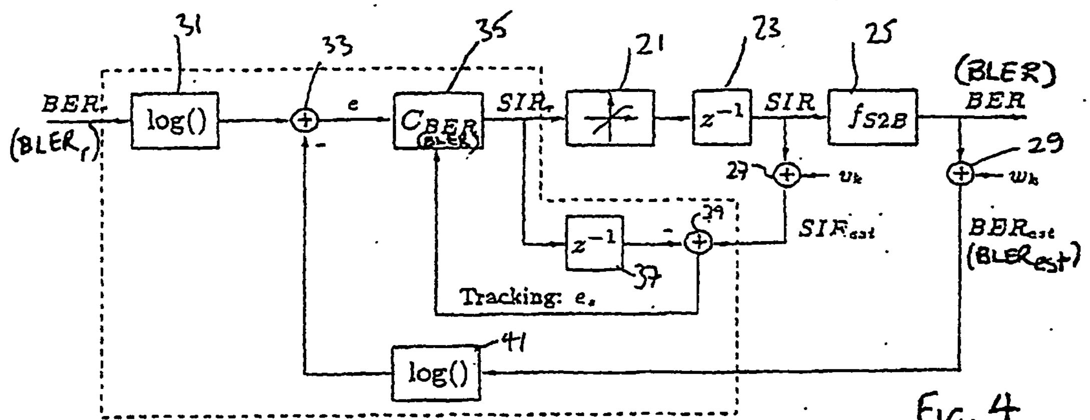
31
33
35
21
23
25
(BLER)
BER
BER_r
(BLER_r)
log()
e
C_BER
(BLER)
SIR_r
z^-1
SIR
f_S2B
29
27
v_k
w_k
SIR_est
BER_est
(BLER_est)
z^-1
37
Tracking: e_s
log()
41

Fig. 4

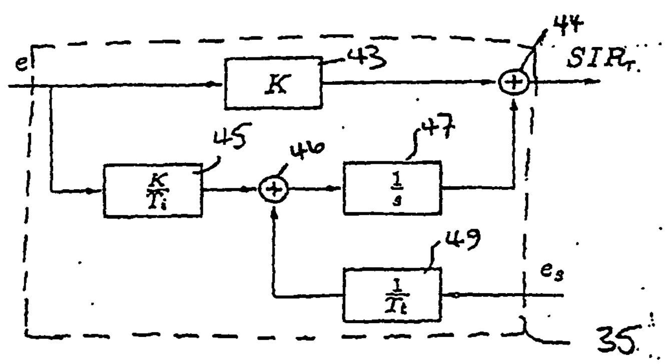
e
K
43
44
SIR_r
K/T_i
45
46
1/s
47
1/T_t
49
e_s
35

Fig. 5